EFFECT OF INCORPORATION OF WHEAT STRAW AND NITROGEN ADDITION ON THE FLUX OF SOIL GASES (CH_4 AND N_2O) AT TWO MOISTURE AND TEMPERATURE REGIMES

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ABSTRACT

Methane and nitrous oxide contribute to global warming of the earth's atmosphere. The concentration of CH_4 and N_2O in the atmosphere is increasing at an alarming rate of 1% and 0.25% yr^{-1}, respectively. Little information is available about the effect of agronomic practices on soil gases emitted from cultivated soils in the prairies. An incubation study was undertaken to understand the effects of agronomic management practices and environmental factors on CH_4 and N_2O emissions from a cultivated soil. Methane production was preceded by a two week lag phase, and it was emitted only from submerged soils incubated at 25°C. Addition of straw enhanced the emission and N addition reduced the rate of CH_4 production. Soil incubated at -30kPa moisture may act as a sink for methane. Emission of N_2O was observed within 2 days of submergence and was maximum when nitrogen alone was added to the soil. Addition of wheat straw along with nitrogen decreased the emission of N_2O as compared to nitrogen alone. Temperature of 10°C and moisture at -30kPa limited the emissions of N_2O from the soil.

1. INTRODUCTION

Global warming of earth from green house effect and ozone depletion is of prime concern among the scientific community. The global warming of our planet is due to the increase of several compounds (CH_4, N_2O, CO_2 and Chlorofluoro carbon) in the atmosphere. These compounds result from burning fossil fuel, deforestation, and overcultivation. Among these problem compounds, CH_4, N_2O and CO_2 are produced in natural and agroecosystem. The level of CH_4,

N_2O and CO_2 in the atmosphere is rising annually at a rate of 0.5%, 1.0%, and 0.2% to 0.3%, respectively (Bouwman and Sombroek, 1990). This may lead to increases in temperature of the earth atmosphere by about 3°C over a time span of 50 years (Scharpenseel and Becker-Heineman, 1990). The impact of this climate change may be extremely diverse and difficult to predict. This change will influence soil temperature and moisture regime, pH, base saturation, fertility status, surface litter and biological activity.

Our understanding of the soil gas emission is poor. The total flux and factor controlling the formation and emission of these gases are unknown. Presently, little is known about the effect of different agronomic management practices on soil gases emitted from cultivated farmland in the prairies. Therefore, this experiment studied the effect of wheat straw incorporation and nitrogen addition on the emission of CH_4 and N_2O from a Black Chernozemic soil at two temperature and moisture regimes.

2. MATERIAL AND METHODS

2.1 Soil sampling

On Oct. 7, 1991, a total of 216 undisturbed soil cores (2.5" O.D. X 4.5" L) were taken from a farm field near Blane Lake in the Black Chernozem zone of Saskatchewan. The soil was loam in texture having organic matter and pH of 5.5% and 6.6, respectively. Soil cores were sealed with parafilm and then packed in plastic bags. The cores were transported to the laboratory and stored at 4°C until used for the incubation study.

2.2 Incubation of soil cores

Soil cores were preincubated at two temperatures (25°C and 10°C) for 72h. The bottom of soil cores was sealed with water proof tape. Soil cores were treated with two levels of wheat straw (0 and 0.5% w/w), two levels of nitrogen (0 and 56 kg N ha^{-1} added as NH_4NO_3), and two moisture levels (-30kPa {23%, oven dry basis} and submergence {60%, oven dry basis}). The experiment was designed as a replicated factorial system. Wheat straw was chopped into 1/2" length and mixed with 1" of top soil. Soil cores were placed in mason jars (1.9L Capacity) sealed with a lid fitted with rubber serum stopper. Head space of treated cores was sampled every 2 to 4 days, and after each sampling, jars were opened to allow equilibration of head space atmosphere with atmospheric air.

2.3 Analysis of soil gases

Soil gases accumulated in the mason jars were analyzed for CH_4 and N_20 using gas chromatography. Methane was analyzed using a Hewlett Packard 5890 series II Gas Chromatograph on a 6' Porapak-Q packed column (Column Temp. 25°C, Detector Temp. 250°C, He flow rate 28 ml min^{-1}) using FID detector. Nitrous oxide was analyzed on a Hewlett Packard 5710A having a 9' column packed with Porapak-Q (Column Temp. 80°C, Detector Temp. 300°C, carrier gas flow rate 35 ml min^{-1}) using Ni^{63} electron capture detector and P5 carrier gas (5% methane balance argon).

3. RESULTS AND DISCUSSION

3.1 Effect of wheat straw and nitrogen on methane emission

The data of methane emission under submergence at 25°C is presented in figures 3.1 and 3.2. Methane was not emitted from the soil in the first two weeks, and increased abruptly thereafter, especially in the straw treated soils. The initial lag period of 2 weeks may indicate build up of low molecular weight organic compounds. These type of substrate are essential for the activity of methanogenic bacteria (Atlas 1984). It is also noticed that addition of nitrogen along with straw decreased the rate of methane emission. Methane emission at 10°C under submergence was negligible and its concentration was very close to that in the air (data not shown). Yagi et al (1990) observed a similar effect of temperature on methane emission. Methane could not be detected in the jars with soils incubated at -30kPa (data not shown). This indicates that soil may act as a sink for methane under low soil moisture level. Similar results were reported by Mosier et al. (1991) in a study conducted at three sites in native, fertilized and cultivated grassland soils.

3.2 Effect of wheat straw incorporation and nitrogen addition on emission of nitrous oxide

The rates of N_2O emission from a Blane Lake soil is presented in figures 3.3, 3.4, 3.5 and 3.6. under submerged conditions, N_2O was emitted quickly (within 2 days) from the soil and addition of straw enhanced the emission of N_2O. The latter may be associated with a larger population of active denitrifiers, greater substrate-C availability and reducing soil conditions. The highest rate of N_2O emission was observed when ammonium nitrate alone was added to the soil. Incorporation of wheat straw along with nitrogen lowered the N_2O emission as compared to nitrogen treatment. This may relate to a more efficient use of N by growing denitrifiers. In general, the rate of N_2O emission decreased with time and tended to level off after 3 to 4 weeks of incubation. The level of soil moisture had an important effect on N_2O emissions. The rate of denitrification was 10 times higher in the submerged soil (figures 3.3 and 3.4). Temperature exerted similar but smaller effects on N_2O emission (i.e. figures 3.3 verses 3.5).

4. SUMMARY

We studied the effect of wheat straw incorporation and nitrogen addition on the emissions of CH_4 and N_2O from a Black Chernozem. Methane was only emitted from the submerged soil incubated at 25°C, however, a lag phase of 2 weeks was observed before CH_4 production. The rate of methane emission was highest when wheat straw was added to the soil. The Black Chernozem may act as a sink for methane under aerobic conditions. Emission of N_2O was rapid and the highest rate was observed when nitrogen alone was added to the soil. In comparison, addition of wheat straw along with nitrogen decreased the N_2O emission as compared to the nitrogen only treatment. On average, Low temperature (10°C) and moisture (-30kPa) decreased the rate of N_2O emission by 30% to 40% and 70% to 80%, respectively.

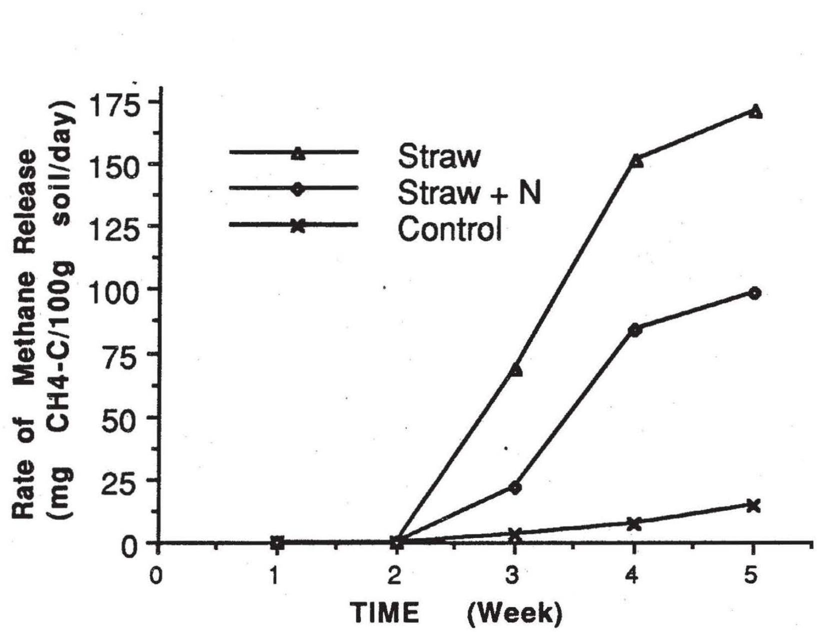

Figure 3.1 Effect of wheat straw incorporation and nitrogen addition on the rate of CH_4 emission from a submerged Black Chenozem incubated at 25°C.

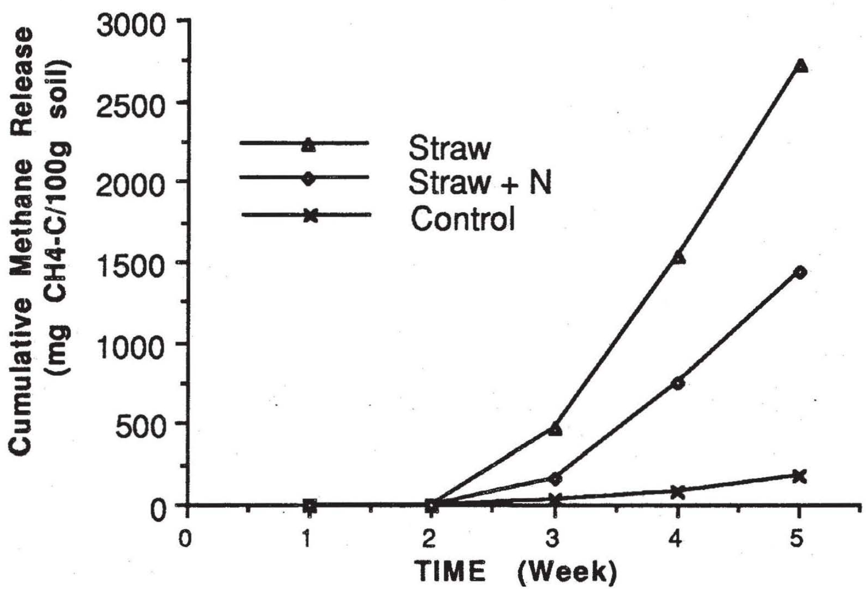

Figure 3.2 Effect of wheat straw incorporation and nitrogen addition on CH_4 emission from a submerged Black Chenozem incubated at 25°C.

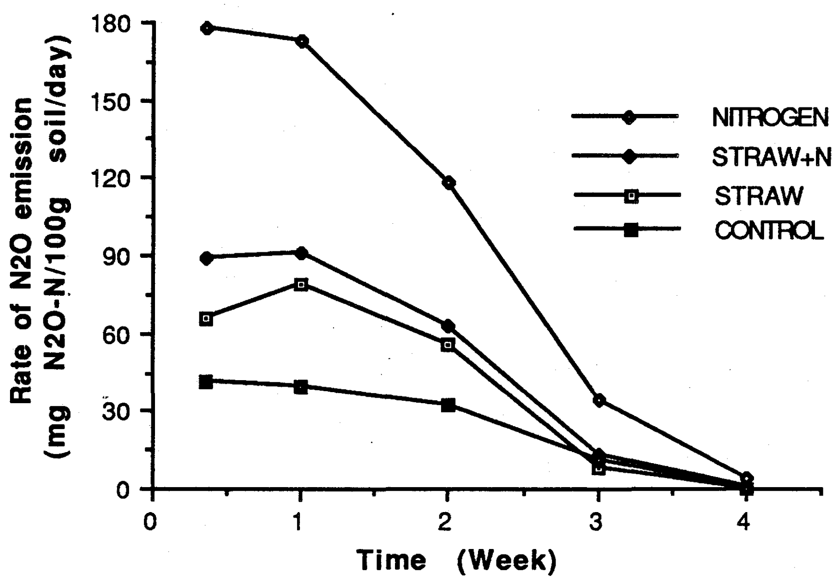

Figure 3.3 Effect of wheat straw incorporation and nitrogen addition on the rate of N_2O emission from a submerged Black Chernozem incubated at 25°C.

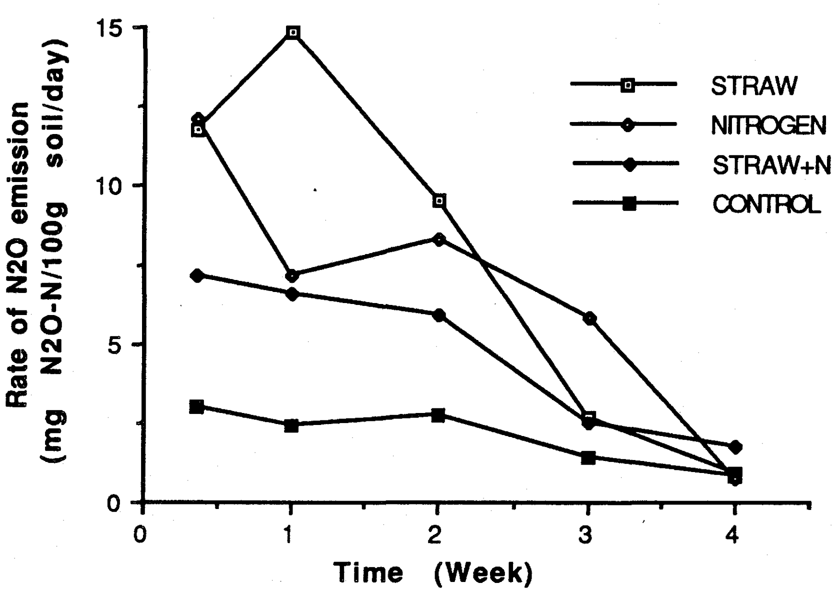

Figure 3.4 Effect of wheat straw incorporation and nitrogen addition on the rate of N_2O emission from a Black Chernozem incubated at -30kPa soil moisture and 25°C.

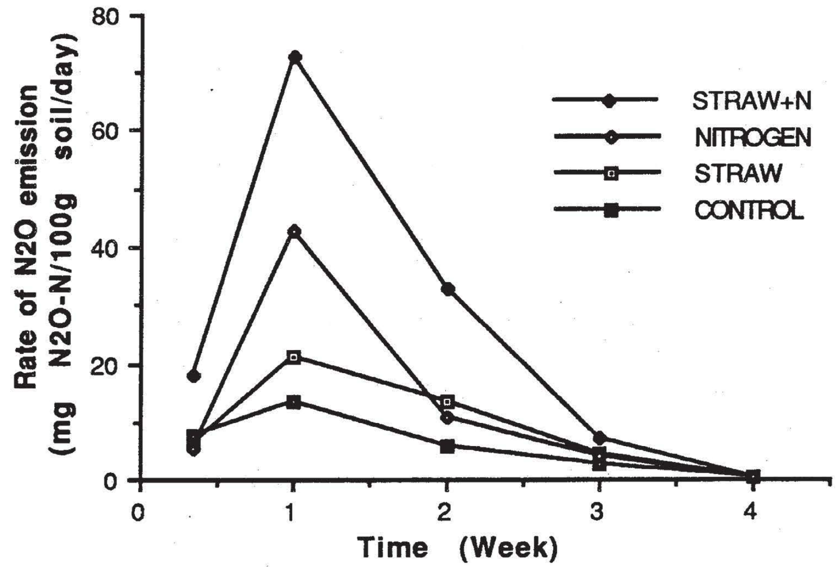

Figure 3.5 Effect of wheat straw incorporation and nitrogen addition on the rate of N_2O emission from a submerged Black Chernozem incubated at 10°C.

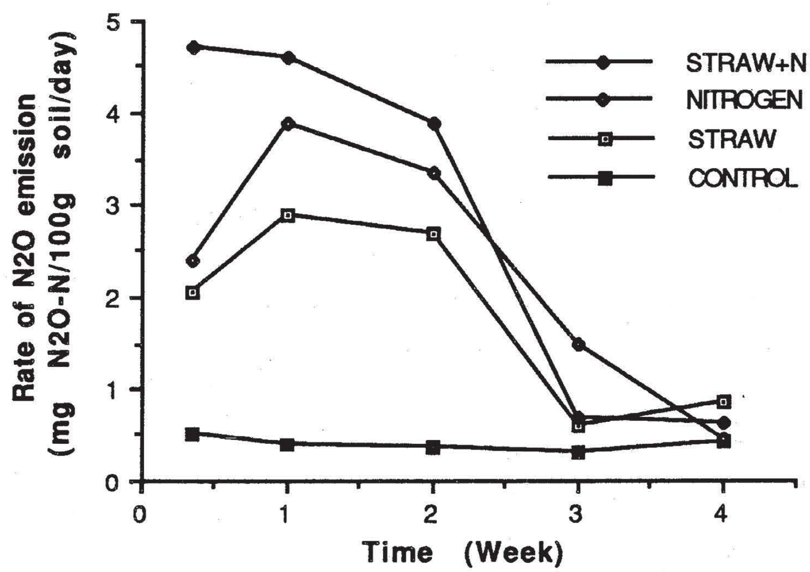

Figure 3.6 Effect of wheat straw incorporation and nitrogen addition on the rate of N_2O emission from a Black Chernozem incubated at -30kPa soil moisture and 10°C.

5. REFERENCES

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